SITE QUALITY ASSURANCE PROJECT PLAN

Tooter Center Site
80 Herricks Road
Mineola, New York 11501

Prepared by:

Removal Support Team
Roy F. Weston, Inc.
Federal Programs Division
Edison, New Jersey 08837

Prepared for:

U.S. Environmental Protection Agency
Region II - Response and Prevention Branch
Edison, New Jersey 08837

DCN #: RST-02-F-00471
TDD #: 02-02-01-0014
EPA Contract No.: 68-W-00-113

Approved by:

RST

Date: 1/23/02

John Brennan
Site Project Manager

RST

Date: 01/28/02

Smita Sumbaly, RST
Quality Assurance Officer

EPA

Date: 1/23/02

Lou DiGuardia
On-Scene Coordinator

361199

TABLE OF CONTENTS

1.0 INTRODUCTION 1

2.0 PROJECT DESCRIPTION 1

3.0 PROJECT ORGANIZATION AND RESPONSIBILITIES 1

4.0 DATA USE OBJECTIVES, QA OBJECTIVES 2
- 4.1 Data Use Objectives 2
- 4.2 QA Objectives 2

5.0 APPROACH AND SAMPLING PROCEDURES 5
- 5.1 Sampling Design 5
- 5.2 Schedule of Activities 5
- 5.3 Sampling Equipment 5
- 5.4 Sample Identification System 6
- 5.5 Standard Operating Procedures (SOPs) 6
  - 5.5.1 Sample Documentation 6
  - 5.5.2 Sampling SOPs 7
  - 5.5.3 Sample Handling and Shipment 7
- 5.6 Sample Containers 8
- 5.7 Disposal of PPE and Contaminated Sampling Materials 8

6.0 SAMPLE CUSTODY 8

7.0 FIELD INSTRUMENT CALIBRATION AND PREVENTIVE MAINTENANCE . 8

8.0 ANALYTICAL METHODS 9

9.0 DATA REDUCTION, VALIDATION, AND REPORTING 9
- 9.1 Deliverables 9
- 9.2 Data Validation 10

10.0 FIELD QUALITY CONTROL CHECKS AND FREQUENCY 10

11.0 SYSTEM AUDIT 11

12.0 CORRECTIVE ACTION 11

The following elements are provided in the RST Generic Quality Assurance Project Plan (QAPP) and are included by reference:

QA REPORTS TO MANAGEMENT
PREVENTIVE MAINTENANCE PROCEDURES AND SCHEDULES
RECORDS MANAGEMENT SYSTEM
LOGBOOK PROGRAM
QUALITY-RELATED DOCUMENTS
INSPECTION/ACCEPTANCE REQUIREMENTS FOR SUPPLIES AND CONSUMABLES

LIST OF ATTACHMENTS

ATTACHMENT A:	Site Maps
ATTACHMENT B:	Air Data Sheets
ATTACHMENT C:	NIOSH Method 1003
ATTACHMENT D:	EPA/ERT SOP No. 2008 - General Air Sampling EPA/ERT SOP No. 2103 - Charcoal Tube Sampling

1.0 INTRODUCTION

Presented herein is the Site Quality Assurance Project Plan (QAPP) for the sampling event to be conducted at the Tooter Center Site by the Region II Removal Support Team (RST). The site QAPP has been developed at the request of the United States Environmental Protection Agency (EPA) in accordance with the RST generic Quality Assurance Project Plan (QAPP).

This plan is based on information currently available and may be modified on site in light of field screening results and other acquired information. All deviations from the QAPP will be noted in the Sampling Trip Report.

2.0 PROJECT DESCRIPTION

In January 2002, following air sampling that showed elevated levels of PCE, EPA installed a sub-slab ventilation system underneath the preschool (Tooter Center) located adjacent to the Jackson Steel Site. EPA has tasked RST to conduct air sampling throughout the interior of the school to confirm the effectiveness of the ventilation system.

3.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

The EPA On-Scene Coordinator (OSC), Lou DiGuardia, will provide overall direction to the staff concerning project sampling needs, objectives, and schedule. The Site Project Manager (SPM), John Brennan, will be the primary point of contact with the OSC. The SPM is responsible for the development and completion of the Sampling QA/QC Plan, project team organization, and supervision of all project tasks, including reporting and deliverables. The Site QC Coordinator will be responsible for ensuring field adherence to the Sampling QA/QC Plan and recording of any deviations. The RST Quality Assurance Officer (QAO), Smita Sumbaly, will be the primary project team site contact with the subcontracted laboratory, if necessary.

RST will arrange for the laboratory analyses and transfer custody of the waste samples for shipment to the appropriate laboratory. The raw analytical data from the laboratory will be provided to the RST for data validation.

The following sampling personnel will work on this project:

Personnel	Responsibility
John Brennan	Project Manager, Field Coordinator, Site QA/QC
Mike Garibaldi	Sampling, Shipping
Smita Sumbaly	Laboratory Procurement
Lou DiGuardia - EPA	Overall Project Direction

The following laboratories will provide the following analyses:

Lab Name/Location	Sample Type	Parameters
Galson Laboratories 6601 Kirkville Road East Syracuse, NY 13057	Charcoal Sorbent Tube	Halogenated Hydrocarbons, especially PCE

A turnaround time of one week for the verbal results and two weeks for the written results has been requested by the OSC.

4.0 DATA USE OBJECTIVES, QA OBJECTIVES

The objective for the use of data collected during the air sampling is to verify the effectiveness of the sub-slab ventilation system being installed underneath of the preschool.

4.1 Data Use Objectives

The overall Quality Assurance (QA) objective for chemical measurement data associated with this sampling event is to provide analytical results that are legally defensible in a court of law. The QA program will incorporate Quality Control (QC) procedures for field sampling, chain of custody, laboratory analyses, and reporting to assure generation of sound analytical results.

The EPA On-Scene Coordinator (OSC) has specified a level of QA-2 for this sampling event. Details of this QA level are provided below.

4.2 QA Objectives

The QA Protocols for a Level 2 QA objective sampling event are applicable to all sample matrices and include:

1. Sample documentation in the form of field logbooks, appropriate field data sheets, and chain of custody records (chain of custody records are optional for field screening locations).

2. Calibration of all monitoring and/or field-portable analytical equipment prior to collection and analyses of samples with results and/or performance check procedures/methods summarized and documented in a field, personal, and/or instrument log notebook.

3. Field or laboratory determined method detection limits (MDLs) will be recorded along with corresponding analytical sample results, where appropriate.

4. Analytical holding times as determined from the time of sample collection through analysis. These will be documented in the field logbook or by the laboratory in the final data

deliverable package.

5. Initial and continuous instrument calibration data.

6. QC blank results (rinsate, trip, method, preparation, instrument, etc.), as applicable.

7. Collection and analysis of blind field duplicate and MS/MSD QC samples to provide a quantitative measure of the analytical precision and accuracy, as applicable.

8. Use of the following QC procedure for QC analyses and data validation:

   Definitive identification - confirm the identification of analytes on 100% of the "critical" samples, via an EPA-approved method; provide documentation such as gas chromatograms, mass spectra, etc.

The objective of this project/event applies to the following parameters:

Table 1: QUALITY ASSURANCE OBJECTIVES

QA Parameters	Matrix	Intended Use of Data	QA Objective
Halogenated Hydrocarbons, especially PCE	Air	Confirm effectiveness of ventilation system	QA-2

A Field Sampling Summary is attached in Table 2 and a QA/QC Analysis and Objectives Summary is attached in Table 3. Section 5.1, Sampling Design, provides information on the analyses to be performed.

TABLE 2:

FIELD SAMPLING SUMMARY

Analytical Parameters	Matrix	Container Size	Preservative	Holding Time[1]	Subtotal Samples	Lot Blanks[2]	Field Blanks[3]	Trip Blanks	Duplicate Samples	Total Field Samples
Halogenated Hydrocarbons, especially PCE	Air	Solid Sorbent Tube - 150 mg Gilian ® cat No. 10225	20°C (None)	30 days to analysis, 7 days to extraction	13	2	1	1	3*	16

*Extra duplicates requested by OSC

1 Holding time from date of sampling.
2 Not required for QA-1 (screening) and high-concentration liquids.
3 Only required if non-dedicated sampling equipment to be used. NR - not required, dedicated sampling equipment to be used.

TABLE 3

QA/QC ANALYSIS AND OBJECTIVES SUMMARY

Analytical Parameters	Matrix	Analytical Method Reference	QA/QC Quantitation Limits	QA Objective
Halogenated Hydrocarbons	Air	NIOSH Method 1003, Modified	10 ug/m^3	QA-2

Note: CLP-format deliverables required for all data packages.

5.0 APPROACH AND SAMPLING PROCEDURES

In addition to the following, the approach and sampling procedures will be conducted in accordance with Sections B1 and B4 of the EPA Region II RST QAPP.

RST will conduct air sampling at the preschool located adjacent to the Jackson Steel Site. Previous air sampling has shown there to be elevated levels of tetrachloroethylene inside of the preschool.

This sampling design is based on information currently available and may be modified on site in light of field screening results and other acquired information. All deviations from the sampling plan will be noted in the Sampling Trip Report.

5.1 Sampling Design

A sub-slab ventilation system is currently being installed underneath of the preschool. RST will conduct air sampling in up to twelve rooms inside of the preschool to determine the effectiveness of the ventilation system. In addition, one sample will be collected outside of the school. This sample will serve as a background level. The samples will be submitted for analysis by Modified NIOSH Method 1003, Halogenated Hydrocarbons (Attachment C). Outdoor weather conditions will be noted in the site log book as well as interior temperature, barometric pressure and relative humidity.

QA/QC samples will include the submission of one field blank (the field blank tube is broken and closed at the site but no air is sampled) and one trip blank (the trip blank tube is broken and closed right before sample shipment at the site but no air is sampled). Two unopened charcoal tubes will be submitted to the laboratory to provide lot blanks and sufficient sorbent for method blanks, calibration standards and additional lab analysis. Duplicate samples will be collected at the rate of one per ten samples. One additional duplicate sample will be submitted at the request of the OSC. Field duplicate samples provide an indication of analytical variability and analytical error and will not be identified to the laboratory.

This sample design is based on information currently available and may be modified on site in light of field screening results and other acquired information. All deviations from the sampling plan will be noted in the Sampling Trip Report.

5.2 Schedule of Activities

Proposed Start Date	Activity	End Date
January 24, 2002	Air Sampling	January 24, 2002

5.3 Sampling Equipment

Samples will be collected with sorbent tubes (coconut based charcoal - 50/100mg, Gilian® cat No. 10225) connected to SKC (model 224-PCXR4) personal sampling pumps for a period of 10 hours. A flow rate of 0.2 L/min for 600 minutes will be used to collect the samples. Pump flow rates will be measured before and after sample collection using a primary dry cell flow meter.

5.4 Sample Identification System

Each sample collected by Region II RST will be designated by a code which will identify the site. The code will be a site-specific project tracking number. The code for the Tooter Center Site is 'TC'. The media type will follow the numeric code. A hyphen will separate the site code and media type. Specific media types are as follows:

A - Air

After the media type, the sequential sample numbers will be listed. A duplicate sample will be identified in the same manner as other samples and will be distinguished and documented in the field logbook.

5.5 Standard Operating Procedures (SOPs)

5.5.1 Sample Documentation

All sample documents will be completed legibly, in ink. Any corrections or revisions will be made by lining through the incorrect entry and by initialing the error.

<u>FIELD LOGBOOK</u>

The field logbook is essentially a descriptive notebook detailing site activities and observations so that an accurate account of field procedures can be reconstructed in the writer's absence. All entries will be dated and signed by the individuals making the entries, and should include (at a minimum) the following:

1. Site name and project number
2. Name(s) of personnel on site
3. Dates and times of all entries (military time preferred)
4. Descriptions of all site activities, site entry and exit times
5. Noteworthy events and discussions
6. Weather conditions
7. Site observations
8. Sample and sample location identification and description*
9. Subcontractor information and names of on-site personnel
10. Date and time of sample collections, along with chain of custody information
11. Record of photographs
12. Site sketches

* - The description of the sample location will be noted in such a manner as to allow the reader to reproduce the location in the field at a later date.

SAMPLE LABELS

Sample labels will clearly identify the particular sample, and should include the following:

1. Site/project number.
2. Sample identification number.
3. Sample collection date and time.
4. Designation of sample (grab or composite).
5. Sample preservation.
6. Analytical parameters.
7. Name of sampler.

Sample labels will be written in indelible ink and securely affixed to the sample container. Tie-on labels can be used if properly secured.

CUSTODY SEALS

Custody seals demonstrate that a sample container has not been tampered with, or opened. The individual in possession of the sample(s) will sign and date the seal, affixing it in such a manner that the container cannot be opened without breaking the seal. The name of this individual, along with a description of the sample packaging, will be noted in the field logbook.

5.5.2 Sampling SOPs

The following Sampling SOPs (Attachment D) will be used for this project:

EPA/ERT SOP No. 2008 - General Air Sampling
EPA/ERT SOP No. 2103 - Charcoal Tube Sampling

5.5.3 Sample Handling and Shipment

Each sample will be capped and packaged according to the following protocol. All capped samples will be placed in zip-lock bags and labeled with the sample number, time and date of collection, analyses requested and preservative used. Sealed bags will be placed in plastic coolers and delivered to the lab. All packaging will conform to IATA Transportation regulations for overnight carriers.

All sample documents will be sealed in a plastic bag and affixed to the underside of each cooler lid. The lid will be sealed and affixed on at least two sides with custody seals so that any sign of tampering is easily visible.

5.6 Sample Containers

All sample containers will meet the QA/QC specifications in OSWER Directive 9240.0-05A, "Specifications and Guidance for Contaminant Free Sample Containers".

5.7 Disposal of PPE and Contaminated Sampling Materials

All used PPE and disposable sampling equipment will be disposed of at the EPA facility in appropriate trash receptacles. No PPE and equipment will be disposed of on-site.

6.0 SAMPLE CUSTODY

In addition to the following, the Sample Custody procedure will be conducted in accordance with Section B3 of the Region II RST QAPP.

A chain of custody record will be maintained from the time the sample is taken to its final deposition. Every transfer of custody must be noted and signed for, and a copy of this record kept by each individual who has signed. When samples (or groups of samples) are not under direct control of the individual responsible for them, they must be stored in a locked container sealed with a custody seal. Specific information regarding custody of the samples projected to be collected on the weekend will be noted in the field logbook.

The chain of custody record should include (at minimum) the following:

- 0.01 Sample identification number
- 0.02 Sample information
- 0.03 Sample location
- 0.04 Sample date
- 0.05 Name(s) and signature(s) of sampler(s)
- 0.06 Signature(s) of any individual(s) with custody of samples

A separate chain of custody form must accompany each cooler for each daily shipment. The chain of custody form must address all samples in that cooler, but not address samples in any other cooler. This practice maintains the chain of custody for all samples in case of mis-shipment.

7.0 FIELD INSTRUMENT CALIBRATION AND PREVENTIVE MAINTENANCE

In addition to the following, the Field Instrument and Preventative Maintenance procedure will be conducted in accordance with Section B6 of the Region II RST QAPP.

The sampling team is responsible for assuring that a calibration/maintenance log will be brought into the field and maintained for each measuring device. Each log will include at a minimum, where applicable:

- name of device and/or instrument calibrated
- device/instrument serial and/or ID number
- frequency of calibration
- date of calibration
- results of calibration
- name of person performing the calibration
- identification of the calibrant

Equipment to be used each day will be calibrated prior to the commencement of daily activities.

8.0 ANALYTICAL METHODS

Analytical methods to be utilized in the analyses of samples collected during this sampling event are detailed in Table 3.

9.0 DATA REDUCTION, VALIDATION, AND REPORTING

9.1 Deliverables

The RST SPM, John Brennan, will maintain contact with the EPA OSC, Lou DiGuardia to keep him informed about the technical and financial progress of this project. This communication will commence with the issuance of the work assignment and project scoping meeting. Activities under this project will be reported in status and trip reports and other deliverables (e.g., analytical reports, final reports) described herein. Activities will also be summarized in appropriate format for inclusion in monthly and annual reports.

The following deliverables will be provided under this project:

<u>TRIP REPORT</u>

A trip report will be prepared to provide a detailed accounting of what occurred during each sampling mobilization. The trip report will be prepared within one week of the last day of each sampling mobilization. Information will be provided on time of major events, dates, and personnel on site (including affiliations).

<u>MAPS/FIGURES</u>

Maps depicting site layout, contaminant source areas, and sample locations will be included in the trip report, as appropriate.

ANALYTICAL REPORT

An analytical report will be prepared for samples analyzed under this plan. Information regarding the analytical methods or procedures employed, sample results, QA/QC results, chain of custody documentation, laboratory correspondence, and raw data will be provided within this deliverable.

DATA REVIEW

A review of the data generated under this plan will be undertaken. The assessment of data acceptability or usability will be provided separately, or as part of the analytical report.

9.2 Data Validation

Data generated under this QA/QC Sampling Plan will be evaluated according to criteria contained in the Removal Program Data Validation Procedures that accompany OSWER Directive number 9360.4-1 and in accordance with Region II guidelines.

Laboratory analytical results will be assessed by the data reviewer for compliance with required precision, accuracy, completeness, representativeness, and sensitivity.

10.0 FIELD QUALITY CONTROL CHECKS AND FREQUENCY

In addition to the following, the Field Quality Control Checks and Frequency procedure will be conducted in accordance with Section B7 of the Region II RST QAPP.

This section details the Quality Assurance/Quality Control (QA/QC) requirements for field activities performed during the sampling effort.

QA/QC samples will include the collection of one field duplicate and one matrix spike/matrix spike duplicate sample for each matrix (soil/sediment) at a ratio of 1 per 20 samples. Extra sample volume will be submitted to allow the laboratory to perform matrix spike sample analysis. This analysis provides information about the effect of sample matrix on digestion and measurement methodology. Field duplicate samples provide an indication of analytical variability and analytical error and will not be identified to the laboratory.

Field Rinsate Blanks will be collected when non-dedicated sampling equipment is used. A field rinsate blank will consist of distilled deionized (DI), demonstrated analyte-free water that has been poured over decontaminated sampling equipment. The field rinsate blank analytical results will be utilized in evaluation of potential cross contamination resulting from inadequate decontamination only if non-dedicated sampling equipment is used. The frequency of field rinsate blank collection is one blank per decontamination event per type of equipment, not to exceed more than one per day. Blanks will be collected for all parameters of interest (excluding physical parameters) and shipped with the samples collected the same day. Field rinsate blanks will be collected by Region II RST.

Field rinsate blanks will be collected in accordance with the procedure listed below:

1) Decontaminate sampling equipment using the procedure specified in Section 3.3 of this plan.

2) Pour DI water over the sampling device and collect the rinsate in the appropriate sample containers.

11.0 SYSTEM AUDIT

In addition to the following, the System Audit procedure will be conducted in accordance with Section C1 of the Region II RST QAPP.

The Field QA/QC Officer will observe sampling operations and review subsequent analytical results to ensure compliance with the QA/QC requirements of the project/sampling event.

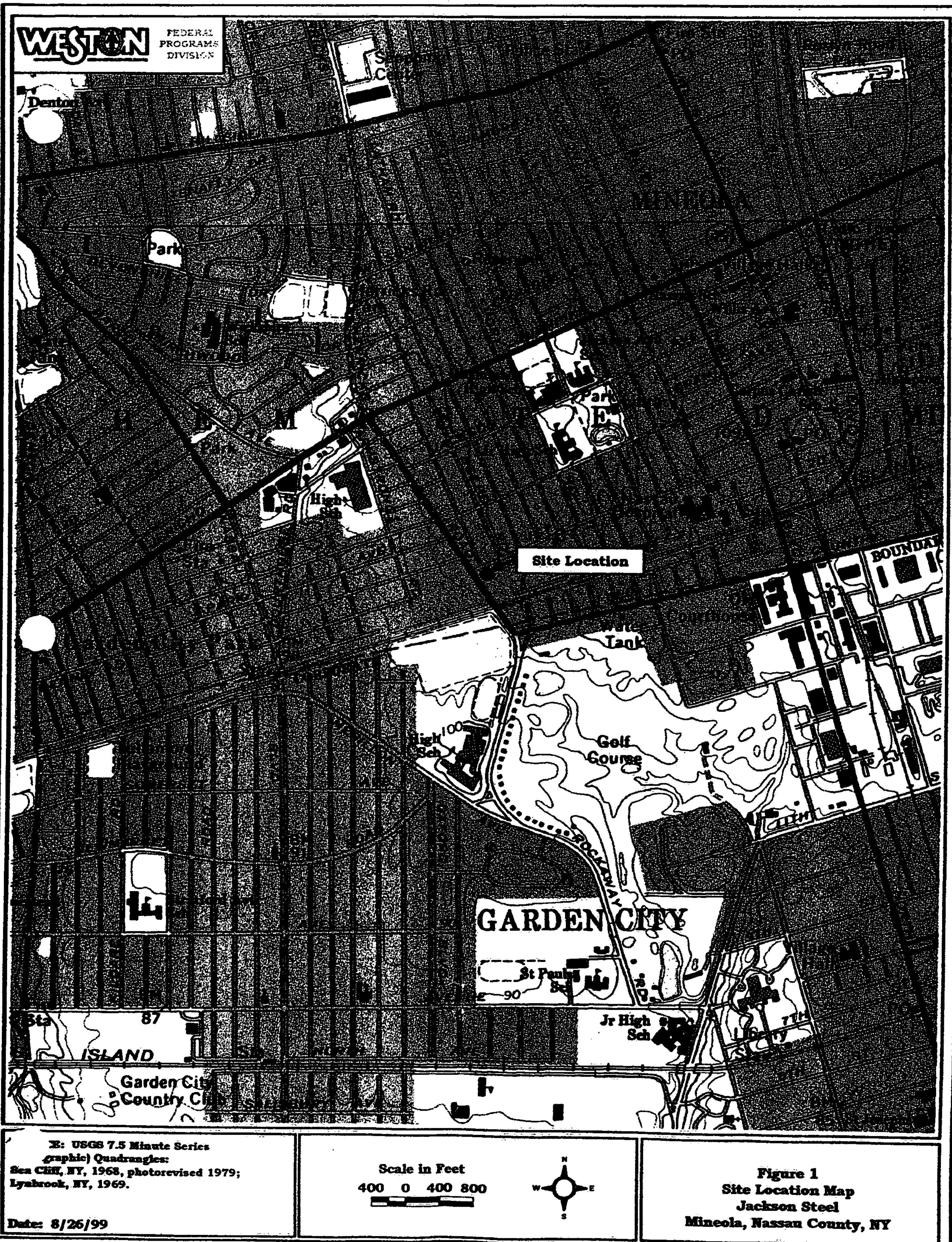
12.0 CORRECTIVE ACTION

In addition to the following, the Corrective Action procedure will be conducted in accordance with Section C1 of the Region II RST QAPP.

All provisions will be taken in the field and laboratory to ensure that any problems that may develop will be dealt with as quickly as possible to ensure the continuity of the project/sampling events. Any deviations from this sampling plan will be noted in the final report.

ATTACHMENT A

Site Maps



E: USGS 7.5 Minute Series
graphic) Quadrangles:
Sea Cliff, NY, 1968, photorevised 1979;
Lynbrook, NY, 1969.

Date: 8/26/99

Figure 1
Site Location Map
Jackson Steel
Mineola, Nassau County, NY

ATTACHMENT B

Air Data Sheets

REGION II REMOVAL SUPPORT TEAM (RST)
AIR SAMPLING DATA SHEET

Site Name: ______________________

U.S. EPA OSC: ______________________

RST Member(s): ______________________

Sample ID:			
Location:			
Date:			
Pump ID #:			
Sample Media:			
Flow Rate: (Final)			
Flow Rate: (Start)			
Flow Rate: (Averaged)			
Finish: Time			
Start: Time			
Elapsed: Time (min)			
Calculated: Sample Volume			
Pump Fault (Y/N)?			

Comments/Weather:

____

____

ATMOSPHERIC CONDITIONS

SITE:______________________________

DATE:______________________________

SAMPLE NUMBER	SAMPLE LOCATION	AVERAGE TEMPERATURE (°F)	AVERAGE BAROMETRIC PRESSURE (INCHES)	AVERAGE RELATIVE HUMIDITY (%)

ATTACHMENT C

NIOSH Method 1003

Table 1 MW: Table 1 CAS: Table 1 RTECS: Table 1

METHOD: 1003, Issue 2	**EVALUATION: PARTIAL**	**Issue 1: 15 February 1984** **Issue 2: 15 August 1994**

OSHA : See TABLE 1
NIOSH: See TABLE 1
ACGIH: See TABLE 1

PROPERTIES: See TABLE 2

COMPOUNDS: (synonyms in Table 1)	benzyl chloride	chlorobromomethane	1,1-dichloroethane	1,1,1-trichloroethane
	bromoform	chloroform	1,2-dichloroethylene	tetrachloroethylene
	carbon tetrachloride	o-dichlorobenzene	ethylene dichloride	1,1,2-trichloroethane
	chlorobenzene	p-dichlorobenzene	hexachloroethane	1,2,3-trichloropropane

SAMPLING

SAMPLER: SOLID SORBENT TUBE (coconut shell charcoal, 100 mg/50 mg)

FLOW RATE: 0.01 to 0.2 L/min

VOL-MIN: Table 3
-MAX: Table 3

SHIPMENT: routine

SAMPLE STABILITY: not determined

BLANKS: 2 to 10 field blanks per set

ACCURACY

RANGE STUDIED: see EVALUATION OF METHOD [1]

BIAS: see EVALUATION OF METHOD [1]

OVERALL PRECISION ($\hat{S}_{rT}$): see EVALUATION OF METHOD [1]

ACCURACY: see EVALUATION OF METHOD [1]

MEASUREMENT

TECHNIQUE: GAS CHROMATOGRAPHY, FID

ANALYTE: compounds above

DESORPTION: 1 mL CS_2, stand 30 min

INJECTION VOLUME: 5 µL

TEMPERATURES: Table 4

CARRIER GAS: N_2 or He, 30 mL/min

COLUMN: Table 4; alternates are SP-2100, Sp-2100 with 0.1% Carbowax 1500 or DB-1 fused silica capillary column

CALIBRATION: standard solutions of analyte in CS_2

RANGE: Table 4

ESTIMATED LOD: 0.01 mg per sample [2]

PRECISION ($\hat{S}_r$): see EVALUATION OF METHOD

APPLICABILITY: See Table 3 for working ranges. This method can be used for simultaneous determination of two or more substances suspected to be present by changing gas chromatographic conditions (i.e., temperature program). High humidity during sampling will prevent organic vapors from being trapped efficiently on the sorbent and greatly decreases breakthrough volume.

INTERFERENCES: None identified. The chromatographic column or separation conditions may be changed to circumvent interferences.

OTHER METHODS: This method combines and replaces P&CAM 127 [3], S101 [4], S110 [5], S113 [6], S114 [7], S115 [8], S122 [9], S123 [10], S126 [11], S133 [12], S134 [13], S135 [14], S281 [15], S314 [16], S328 [17], S335 [18], S351 [19], and Method 1003 (dated 2/15/84).

REAGENTS:

1. Carbon disulfide, chromatographic quality.*
2. Analyte, reagent grade.
3. Calibration stock solutions:
   a. benzyl chloride, 10 mg/mL in n-heptane.
   b. bromoform, 10 mg/mL in n-hexane.
   c. o-dichlorobenzene, 200 mg/mL in acetone.
   d. p-dichlorobenzene, 300 mg/mL in acetone.
   e. hexachloroethane, 25 mg/mL in toluene.
4. Decane, n-undecane, octane or other internal standards (see step 6).
5. Nitrogen or helium, purified.
6. Hydrogen, prepurified.
7. Air, filtered.

* See SPECIAL PRECAUTIONS.

EQUIPMENT:

1. Sampler: glass tube, 7 cm long, 6-mm OD, 4-mm ID, flame-sealed ends with plastic caps, containing two sections of 20/40 mesh activated (600 °C) coconut shell charcoal (front = 100 mg; back = 50 mg) separated by a 2-mm urethane foam plug. A silylated glass wool plug precedes the front section and a 3-mm urethane foam plug follows the back section. Pressure drop across the tube at 1 L/min airflow must be less than 3.4 kPa. Tubes are commercially available (e.g., SKC #226-01).
2. Personal sampling pump, 0.01 to 0.2 L/min, with flexible connecting tubing.
3. Gas chromatograph, FID, integrator and column (see Table 3).
4. Vials, 2-mL, glass, PTFE-lined septum crimp caps.
5. Volumetric flasks, 10-mL.
6. Syringes, 10-µL, readable to 0.1 µL.
7. Pipet, TD, 1-mL, with pipet bulb.

SPECIAL PRECAUTIONS: Carbon disulfide is toxic and a serious fire and explosion hazard (flash point = −30 °C). Work with it only in a hood. Several of the analytes are suspect carcinogens (Table 1). n-Heptane, n-hexane, and acetone are fire hazards.

SAMPLING:

1. Calibrate each personal sampling pump with a representative sampler in line.
2. Break the ends of the sampler immediately before sampling. Attach sampler to personal sampling pump with flexible tubing.
3. Sample at an accurately known flow rate between 0.01 and 0.2 L/min for a total sample size between the limits shown in Table 2.
4. Cap the samplers. Pack securely for shipment.

SAMPLE PREPARATION:

5. Place the front and back sorbent sections of the sampler tube in separate vials. Discard the glass wool and foam plugs.
6. Add 1.0 mL CS_2 to each vial. Cap each vial.
   NOTE: A suitable internal standard, such as decane [16], n-undecane [6,19], or octane [9,13,17] at 0.1% (v/v) may be added at this step and step 8.
7. Allow to stand 30 min with occasional agitation.

CALIBRATION AND QUALITY CONTROL:

8. Calibrate daily with at least six working standards over the appropriate range (Table 3).
   a. Add known amounts of neat analyte or calibration stock solution to CS_2 in 10-mL volumetric flasks and dilute to the mark.
   b. Analyze with samples and blanks (steps 11 and 12).
   c. Prepare calibration graph (peak area vs. mg analyte).

9. Determine desorption efficiency (DE) at least once for each lot of charcoal used for sampling in the range of interest. Prepare three tubes at each of five concentrations plus three media blanks.
   a. Remove and discard back sorbent section of a media blank sampler.
   b. Inject a known amount (2 to 20 μL) of pure analyte, or calibration stock solution (see REAGENTS, 3.), directly onto front sorbent section with a microliter syringe.
   c. Cap the tube. Allow to stand overnight.
   d. Desorb (steps 5 through 7) and analyze together with working standards (steps 11 and 12).
   e. Prepare a graph of DE vs. mg analyte recovered.
10. Analyze three quality control blind spikes and three analyst spikes to insure that the calibration graph and DE graph are in control.

MEASUREMENT:

11. Set gas chromatograph according to manufacturer's recommendations and to conditions given on page 1003-1 and in Table 3. Inject sample aliquot either manually using solvent flush technique or with autosampler.
    NOTE: If peak area is above the linear range of the working standards, dilute with CS_2, reanalyze and apply the appropriate dilution factor in calculations.
12. Measure peak area.

CALCULATIONS:

13. Determine the mass, mg (corrected for DE), of analyte found in the sample front (W_f) and back (W_b) sorbent sections and in the average media blank front (B_f) and back (B_b) sorbent sections.
    NOTE: If $W_b > W_f/10$, report breakthrough and possible sample loss.
14. Calculate concentration, C, of analyte in the air volume sampled, V (L):

$$C = \frac{(W_f + W_b - B_f - B_b) \cdot 10^3}{V}, \text{ mg/m}^3.$$

EVALUATION OF METHOD:

Laboratory testing was performed with spiked samples and generated atmospheres using SKC Lot 105 coconut shell charcoal [1]. Results were:

Compound	Range mg/m³	Sample Size	Bias %	Precision Overall	Precision Measurement	Accuracy ±%	Desorption Efficiency	Ref.
Benzyl chloride	2-8	10 L	−8.4	0.096	0.031	25.6	0.90 @ 0.03-0.1 mg	[8]
Bromoform	3-10	10 L	−1.3	0.071	0.043	14.0	0.80 @ 0.025 mg	[7]
Carbon tetrachloride	65-299	15 L	−1.6	0.092	0.037	18.0	0.96 @ 1.3-4.8 mg	[16]
Chlorobenzene	183-736	10 L	0.3	0.056	0.025	11.0	0.91 @ 1.8-7.1 mg	[12]
Chlorobromomethane	640-2655	5 L	3.4	0.061	0.051	14.0	0.94 @ 3.3-13 mg	[6]
Chloroform	100-416	15 L	1.3	0.057	0.047	11.6	0.97 @ 1.8-7.4 mg	[19]
o-Dichlorobenzene	150-629	3 L	−1.9	0.068	0.013	13.7	0.86 @ 0.5-1.9 mg	[14]
p-Dichlorobenzene	183-777	3 L	−4.3	0.052	0.022	12.5	0.91 @ 0.7-2.7 mg	[15]
1,1-Dichloroethane	212-838	10 L	2.6	0.057	0.011	12.4	1.01 @ 1.9-8 mg	[10]
1,2-Dichloroethylene*	475-1915	3 L	−2.9	0.052	0.017	11.3	1.00 @ 2.4-9.5 mg	[5]
Ethylene dichloride	195-819	3 L	−2.0	0.079	0.012	15.7	0.96 @ 0.6-2.5 mg	[9]
Hexachloroethane	5-25	10 L	−6.6	0.121	0.014	25.4	0.98 @ 0.05-0.2 mg	[4]
1,1,1-Trichloroethane	904-3790	3 L	−0.6	0.054	0.018	10.6	0.99 @ 2.9-11 mg	[17]
Tetrachloroethylene	655-2749	3 L	−7.2	0.052	0.013	15.1	0.96 @ 2.1-8 mg	[18]
1,1,2-Trichloroethane	26-111	10 L	−9.0	0.057	0.010	17.5	0.97 @ 0.3-1.2 mg	[13]
1,2,3-Trichloropropane	163-629	10 L	2.1	0.068	0.027	14.2	0.95 @ 1.5-6 mg	[11]

*Isomer used (i.e., cis- or trans-) in evaluation unknown.

REFERENCES:

[1] Documentation of the NIOSH Validation Tests, S101, S110, S113, S114, S115, S122, S123, S126, S133, S134, S135, S281, S314, S328, S335, S351, U.S. Department of Health, Education, and Welfare, Publ. (NIOSH) 77-185 (1977), available as Stock No. PB 274-248 from NTIS, Springfield, VA 22161.

[2] User check, UBTL, NIOSH Sequences #3990-T, 3990-U and 3990-W (NIOSH, unpublished, November 3, 1983) and 4304-J (NIOSH, unpublished, April 3, 1984).

[3] NIOSH Manual of Analytical Methods, 2nd ed., V. 1., P&CAM 127, U.S. Department of Health, Education, and Welfare, Publ. (NIOSH) 77-157-A (1977).

[4] Ibid., V. 2., S101, U.S. Department of Health, Education, and Welfare, Publ. (NIOSH) 77-157-B (1977).

[5] Ibid., S110.

[6] Ibid., S113.

[7] Ibid., S114.

[8] Ibid., S115.

[9] Ibid., S122.

[10] Ibid., S123.

[11] Ibid., S126.

[12] Ibid., S133.

[13] Ibid., S134.

[14] Ibid., V. 3, S135, U.S. Department of Health, Education, and Welfare, Publ. (NIOSH) 77-157-C (1977).

[15] Ibid., S281.

[16] Ibid., S314.

[17] Ibid., S328.

[18] Ibid., S335.

[19] Ibid., S351.

[20] NIOSH/OSHA Occupational Health Guidelines for Chemical Hazards, U.S. Department of Health and Human Services, Publ. (NIOSH) 81-123 (1981), available as Stock #PB83-154609 from NTIS, Springfield, VA 22161.

[21] NIOSH Current Intelligence Bulletin 27, Chloroethanes: Review of Toxicity, U.S. Department of Health, Education, and Welfare, Publ. (NIOSH) 78-181 (1978).

[22] NIOSH Current Intelligence Bulletin 20, Tetrachloroethylene (Perchloroethylene), U.S. Department of Health, Education, and Welfare, Publ. (NIOSH) 78-112 (1978).

[23] Criteria for a Recommended Standard...Occupational Exposure to Benzyl Chloride, U.S. Department of Health, Education, and Welfare, Publ. (NIOSH) 78-182 (1978).

[24] Criteria for a Recommended Standard...Occupational Exposure to Carbon Tetrachloride, U.S. Department of Health, Education, and Welfare, Publ. (NIOSH) 76-133 (1976).

[25] Criteria for a Recommended Standard...Occupational Exposure to Chloroform, U.S. Department of Health, Education, and Welfare, Publ. (NIOSH) 75-114 (1975).

[26] Criteria for a Recommended Standard...Occupational Exposure to Ethylene Dichloride, U.S. Department of Health, Education, and Welfare, Publ. (NIOSH) 76-139 (1976).

[27] Criteria for a Recommended Standard...Occupational Exposure to 1,1,1-Trichloroethane, U.S. Department of Health, Education, and Welfare, Publ. (NIOSH) 76-184 (1976).

[28] Criteria for a Recommended Standard...Occupational Exposure to Tetrachloroethylene (Perchloroethylene), U.S. Department of Health, Education, and Welfare, Publ. (NIOSH) 76-185 (1976).

METHOD REVISED BY:

G. David Foley and Yvonne T. Gagnon, NIOSH/DPSE; methods originally validated under NIOSH Contract CDC-99-74-45.

TABLE 1. GENERAL INFORMATION.

Compound RTECS	Synonyms	OSHA/NIOSH/ACGIH (ppm)
Benzyl chloride[a] ($C_6H_5CH_2Cl$); XS8925000	(chloromethyl) benzene; α-chlorotoluene; CAS #100-44-7	1/C 1.0/1
Bromoform ($CHBr_3$); PB5600000	tribromomethane; CAS #75-25-2	0.5 (skin)/0.5 (skin)/0.5 (skin)
Carbon tetrachloride[ab] (CCl_4); FG4900000	tetrachloromethane; CAS #56-23-5	10, C 25/STEL 2 (1 h)/5 (skin)
Chlorobenzene (C_6H_5Cl); CZ0175000	monochlorobenzene; phenyl chloride; CAS #108-90-7	75/–/10
Chlorobromomethane (CH_2BrCl); PA5250000	bromochloromethane; Halon 1011; CAS #74-97-5	200/200/200
Chloroform[ab] ($CHCl_3$); FS9100000	trichloromethane; CAS #67-66-3	C 50/STEL 2/10
o-Dichlorobenzene[c] (1,2-$C_6H_4Cl_2$); CZ4500000	1,2-dichlorobenzene; CAS #95-50-1	50/C 50/25 (skin); STEL 50
p-Dichlorobenzene[ac] (1,4-$C_6H_4Cl_2$); CZ45500000	1,4-dichlorobenzene; CAS #106-46-7	75/1.7 (LOQ)/75, STEL 110
1,1-Dichloroethane (CH_3CHCl_2); KI0175000	ethylidene chloride; CAS #75-34-3	100/100/100
1,2-Dichloroethylene (ClCH=CHCl); KV9360000	acetylene dichloride; 1,2-dichloroethene; CAS #540-59-0	200/200/200
Ethylene dichloride[ab] ($ClCH_2CH_2Cl$); KI0525000	1,2-dichloroethane; CAS #107-06-2	50, C 100/1, STEL 2/10
Hexachloroethane[ac] (CCl_3CCl_3); KI4025000	perchloroethane; CAS #67-72-1	1 (skin)/1/1 (skin)
1,1,1-trichloroethane (CH_3CCl_3); KJ2975000	methyl chloroform; CAS #71-55-6	350/C 350/350, STEL 450
Tetrachloroethylene[ab] ($Cl_2C=CCl_2$); KX3850000	perchloroethylene; CAS #127-18-4	100, C 200, P 300/0.4 (LOQ)/ 25, STEL 100
1,1,2-Trichloroethane[ad] (Cl_2CHCH_2Cl); KJ3150000	vinyl trichloride; CAS #79-00-5	10 (skin)/10 (skin)/10 (skin)
1,2,3-Trichloropropane[a] ($CH_2ClCHClCH_2Cl$); TZ9275000	allyl trichloride; glycerol trichlorohydrin; CAS #96-18-4	50/10 (skin)/10 (skin)

[a]Suspect carcinogen [20,21,22]; [b]Group I Pesticide; [c]Group II Pesticide; [d]Group III Pesticide

TABLE 2. PHYSICAL PROPERTIES

Compound RTECS	M.W.	mg/m^3 = 1 ppm @ NTP	Synonyms	Properties
Benzyl chloride ($C_6H_5CH_2Cl$)	126.58	5.17	(chloromethyl) benzene; -chlorotoluene	liquid; BP 179 °C; MP −48 to −43 °C; d 1.100 @ 20 °C; flash pt. 67 °C
Bromoform ($CHBr_3$)	252.75	10.33	tribromomethane	liquid, d 2.887; BP 148 °C; nonflammable
Carbon tetrachloride (CCl_4)	153.84	6.29	tetrachloromethane	liquid; d 1.585; BP 76.7 °C; FP −23.0 °C; VP 91.3 mm @ 20 °C; vapor density (air = 1) 5.3
Chlorobenzene (C_6H_5Cl)	112.56	4.60	monochlorobenzene; phenyl chloride	liquid; d 1.105 @ 25 °C; BP 131.6 °C; MP −45 °C; flash pt. 29.4 °C (CC)
Chlorobromomethane (CH_2BrCl)	129.39	5.29	bromochloromethane; Halon 1011	liquid; d 1.93 @ 20 °C; BP 68 °C; MP −88 °C; nonflammable
Chloroform ($CHCl_3$)	119.39	4.88	trichloromethane	liquid, d 1.485 @ 20 °C; BP 61.2 °C; FP -63.5 °C
o-Dichlorobenzene (1,2-$C_6H_4Cl_2$)	147.00	6.01	1,2-dichlorobenzene	liquid; d 1.284; BP 172 to 179 °C; FP −17 °C; flash pt. 65.5 °C
p-Dichlorobenzene (1,4-$C_6H_4Cl_2$)	147.00	6.01	1,4-dichlorobenzene	solid crystals; d 1.458; BP 173.7 °C; MP 53 °C; sublimes; flash pt. 65.5 °C
1,1-Dichloroethane (CH_3CHCl_2)	98.95	4.05	ethylidene chloride	liquid, d 1.174 @ 20 °C; BP 57 to 59 °C; FP −98 °C
1,2-Dichloroethylene ($ClCH=CHCl$)	96.94	3.96	acetylene dichloride; 1,2-dichloroethene	liquid; transisomer; d 1.257; BP 47 to 49 °C; MP −57°C; cis-isomer; d 1.282; BP 58 to 60 °C; flash pt. 3.9 °C; FP −80 °C
Ethylene dichloride ($ClCH_2CH_2Cl$)	98.96	4.05	1,2-dichloroethane	liquid; d 1.2554 @ 20 °C; BP 83.5 °C; FP −35.5 °C; flash pt. 13 °C; explosive limits in air 6 to 16%
Hexachloroethane (CCl_3CCl_3)	236.74	9.66	perchloroethane	solid; d 2.091; MP 185 °C; BP sublimes at 187 °C
1,1,1-trichloroethane (CH_3CCl_3)	133.42	5.45	methyl chloroform	liquid; d 1.325; BP 75 °C; FP −30.4 °C; nonflammable
Tetrachloroethylene ($Cl_2C=CCl_2$)	165.83	6.78	perchloroethylene	liquid; d 1.625 @ 20 °C; BP 121 °C; FP −22.4 °C
1,1,2-Trichloroethane (Cl_2CHCH_2Cl)	133.41	5.45	vinyl trichloride	liquid; d 1.4432 @ 20 °C; BP 113.7 °C; FP −36.4 °C; VP 19 mm Hg @ 20 °C
1,2,3-Trichloropropane ($CH_2ClCHClCH_2Cl$)	147.43	6.03	allyl trichloride; glycerol trichlorohydrin	liquid; d 1.3888 @ 20 °C; BP 156.2 °C; FP −15 °C; flash pt. 82.2 °C (OC)

TABLE 3. SAMPLING LIMITS.

Compound	Air Sample Volume (L)			Working Range, ppm, at Max Sample Volume
	Min	Max	Target	
Benzyl chloride	6 @ 1 ppm	50	10	0.6 to 5.8
Bromoform	4 @ 0.5 ppm	70	10	0.2 to 4
Carbon tetrachloride	3 @ 10 ppm	150	15	2 to 105
Chlorobenzene	1.5 @ 75 ppm	40	10	10 to 430
Chlorobromomethane	0.5 @ 200 ppm	8	5	18 to 450
Chloroform	1 @ 50 ppm	50	15	2 to 190
o-Dichlorobenzene	1 @ 50 ppm	60	3	16 to 1100
p-Dichlorobenzene	1 @ 75 ppm	10	3	27 to 330
1,1-Dichloroethane	0.5 @ 100 ppm	15	10	4 to 250
1,2-Dichloroethylene	0.2 @ 200 ppm	5	3	16 to 560
Ethylene dichloride	1 @ 50 ppm	50	3	16 to 1320
Hexachloroethane	3 @ 1 ppm	70	10	0.3 to 8.3
1,1,1-Trichloroethane	0.1 @ 350 ppm	8	3	18 to 1450
Tetrachloroethylene	0.2 @ 100 ppm	40	3	9 to 1900
1,1,2-Trichloroethane	2 @ 10 ppm	60	10	1.8 to 64
1,2,3-Trichloropropane	0.6 @ 50 ppm	60	10	3 to 310

TABLE 4. MEASUREMENT PARAMETERS.

Compound	Column*	Temp. (°C) Column/Injector/Detector	Range (mg per sample)
Benzyl chloride	A	160/170/210	0.02 to 0.15
Bromoform	A	130/170/210	0.02 to 0.15
Carbon tetrachloride	B	60/155/200	0.2 to 7
Chlorobenzene	A	105/190/250	0.4 to 10
Chlorobromomethane	A	80/170/210	0.5 to 15
Chloroform	B	75/155/200	0.4 to 11
o-Dichlorobenzene	C	140/225/250	0.1 to 3
p-Dichlorobenzene	A	140/225/275	0.2 to 4
1,1-Dichloroethane	A	50/100/175	0.4 to 12
1,2-Dichloroethylene	A	60/170/210	0.2 to 7
Ethylene dichloride	C	70/225/250	0.1 to 4
Hexachloroethane	D	110/170/210	0.02 to 0.3
1,1,1-Trichloroethane	C	70/225/250	0.8 to 17
Tetrachloroethylene	C	90/225/250	0.4 to 12
1,1,2-Trichloroethane	C	70/250/225	0.05 to 2
1,2,3-Trichloropropane	E	160/180/230	0.3 to 9

*A = 3 m x 3-mm OD stainless steel, 10% SP-1000 on 80/100 mesh Chromosorb WHP.
B = 6 m x 3-mm OD, otherwise same as A.
C = 3 m x 3-mm OD stainless steel, 10% OV-101 on 100/120 mesh Chromosorb WHP.
D = 3 m x 6-mm OD glass, 3% SP-2250 on 80/100 mesh Chromosorb WHP.
E = 3 m x 3-mm OD stainless steel, 10% FFAP on 80/100 mesh Chromosorb WHP.

ATTACHMENT D

EPA/ERT SOPS

GENERAL AIR SAMPLING GUIDELINES

SOP#: 2008
DATE: 11/16/94
REV. #: 0.0

1.0 SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) provides guidance in developing and implementing sampling plans to assess the impact of hazardous waste sites on ambient air. It presents the United States Environmental Protection Agency/Environmental Response Team's (U.S. EPA/ERT's) approach to air sampling and monitoring and identifies equipment requirements. It is not within the scope of this SOP to provide a generic air sampling plan. Experience, objectives, site characteristics, and chemical characteristics will dictate sampling strategy. This SOP does not address indoor air sampling.

Two basic approaches can be used to assess ambient air (also referred to as air pathway assessments): modeling and measurements. The modeling approach initially estimates or measures the overall site emission rate(s) and pattern(s). These data are input into an appropriate air dispersion model, which predicts either the maximum or average air concentrations at selected locations or distances during the time period of concern. This overall modeling strategy is presented in the first three volumes of the Air Superfund National Technical Guidance Series on Air Pathway Assessments[1,2,3]. Specific applications of this strategy are presented in several additional Air Superfund Technical Guidance documents[4].

The measurement approach involves actually measuring the air impact at selected locations during specific time periods. These measurements can be used to document actual air impacts during specific time intervals (i.e., during cleanup operations) or to extrapolate the probable "worst case" concentrations at that and similar locations over a longer time period than was sampled.

This SOP addresses issues associated with this second assessment strategy. This SOP also discusses the U.S. EPA/ERT's monitoring instruments, air sampling kits, and approach to air sampling and monitoring at hazardous waste sites.

These are standard (i.e., typically applicable) operating procedures which may be varied or changed as required, depending on site conditions, equipment limitations, or limitations imposed by the procedure. In all instances, the ultimate procedures employed should be documented and associated with the final report.

Mention of trade names or commercial products does not constitute U.S. EPA endorsement or recommendation for use.

2.0 METHOD SUMMARY

Air monitoring is defined as the use of direct-reading instruments and other screening or monitoring equipment and techniques that provide instantaneous (real-time) data on the levels of airborne contaminants. The U.S. EPA/ERT maintains numerous monitors for real-time measurements. Examples of air monitoring equipment are hand-held photoionization detectors (PID), flame ionization detectors (FID), oxygen/combustible gas detectors, and remote optical sensors.

Air sampling is defined as those sampling and analytical techniques that require either off- or on-site laboratory analysis and therefore do not provide immediate results. Typically, air sampling occurs after use of real-time air monitoring equipment has narrowed the number of possible contaminants and has provided some qualitative measurement of contaminant concentration. Air sampling techniques are used to more accurately detect, identify and quantify specific chemical compounds relative to the majority of air monitoring technologies.

In the Superfund Removal Program, On-Scene Coordinators (OSCs) may request the U.S. EPA/ERT to conduct air monitoring and sampling during the following situations: emergency responses, site assessments, and removal activities. Each of these activities has a related air monitoring/sampling objective that is used to determine the potential hazards to workers and/or the community.

- Emergency Response

  Emergency responses are immediate responses to a release or threatened release of hazardous substances presenting an imminent danger to public health, welfare, or the environment (i.e., chemical spills, fires, or chemical process failures resulting in a controlled release of hazardous substances). Generally these situations require rapid on-site investigation and response. A major part of this investigation consists of assessing the air impact of these releases.

- Removal Site Assessment

  Removal site assessments (referred to as site assessments) are defined as any of several activities undertaken to determine the extent of contamination at a site and which help to formulate the appropriate response to a release or threatened release of hazardous substances. These activities may include a site inspection, multimedia sampling, and other data collection.

- Removal Actions

  Removal actions clean up or remove hazardous substances released into the environment. Removal actions include any activity conducted to abate, prevent, minimize, stabilize, or eliminate a threat to public health or welfare, or to the environment.

Personal risk from airborne contaminants can be determined by comparing the results of on-site monitoring and sampling to health-based action levels such as the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs) and the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs). Residential risk can be determined by comparing the results of off-site monitoring or sampling to health-based action levels such as those developed by the Agency for Toxic Substance and Disease Registry (ATSDR).

The extent to which valid inferences can be drawn from air monitoring/sampling depends on the degree to which the monitoring/sampling effort conforms to the objectives of the event. Meeting the project's objectives requires thorough planning of the monitoring/sampling activities, and implementation of the most appropriate monitoring/sampling and analytical procedures. These issues will be discussed in this SOP.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Preservation, containers, handling and storage for air samples are discussed in the specific SOPs for the technique selected. In addition, the analytical method (i.e., U.S. EPA, National Institute for Occupational Safety and Health [NIOSH], and OSHA Methods) may be consulted for storage temperature, holding times and packaging requirements. After sample collection, the sampling media (i.e., cassettes or tubes) are immediately sealed. The samples are then placed into suitable containers (i.e., whirl bags, resealable bagsor culture tubes) which are then placed into a shipping container.

Use bubble wrap or styrofoam peanuts when packing air samples for shipment. DO NOT USE VERMICULITE.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

Upwind sources can contribute to sample concentration. Natural sources, such as biological waste, can produce hydrogen sulfide and methane which may contribute to the overall contaminant level. Extraneous anthropogenic contaminants (i.e., burning of fossil fuels; emissions from vehicular traffic, especially diesel; volatile compounds from petrochemical facilities; and effluvium from smoke stacks) may also contribute. Air sampling stations should be strategically placed to identify contributing sources.

Photoreactivity or reaction of the parameters of concern may occur with nonrelated compounds [i.e., nitrogen compounds and polyaromatic hydrocarbons

(PAHs)]. Some sorbent media/samples should not be exposed to light during or after sampling due to photochemical effects (i.e., PAHs).

Various environmental factors, including humidity, temperature and pressure, also impact the air sampling methodology, collection efficiency and detection limit. Since the determination of air contaminants is specifically dependent on the collection parameters and efficiencies, the collection procedure is an integral part of the analytical method.

Detection limits depend on the contaminants being investigated and the particular site situation. It is important to know why the data are needed and how the data will be used. Care should be taken to ensure the detection limits are adequate for the intended use of the final results.

Some equipment may be sensitive to humidity and temperature extremes.

5.0 EQUIPMENT/APPARATUS

5.1 Direct Reading Instruments (Air Monitoring Instruments)

There are two general types of direct reading instruments: portable screening devices and specialized analytical instruments. Generally all these techniques involve acquiring, for a specific location or area, continuous or sequential direct air concentrations in either a real-time or semi-real-time mode. None of these instruments acquires true time-weighted average concentrations. In addition, these instruments are not capable of acquiring simultaneous concentration readings at multiple locations, although several are able to sequentially analyze samples taken remotely from different locations. The document, "Guide to Portable Instruments for Assessing Airborne Pollutants Arising from Hazardous Waste Sites[5]," provides additional information about air sampling and monitoring. The hazard levels for airborne contaminants vary. See the ACGIH TLVs and the OSHA PELs for safe working levels. Common screening devices and analytical instruments are described in Appendix A.

5.2 Air Sampling Equipment and Media/Devices

The U.S. EPA/ERT uses the following analytical methods for sampling: *NIOSH Manual of Analytical Methods*[6], *American Society for Testing and Materials (ASTM) Methods*[7], *U.S. EPA Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air*[8,9], and *OSHA Methods*[10]. Additional air sampling references include *Industrial Hygiene and Toxicology* (3rd Ed.)[11] and *Air Sampling Instruments for Evaluation of Atmospheric Contaminants*[12]. These methods typically specify equipment requirements for sampling. Since air sampling is such a diverse technology, no single method or reference is best for all applications. Common sampling equipment and media/devices are described in Appendix B.

5.3 Tools/Material and Equipment List

In addition to equipment and materials identified in Appendices A and B, the following equipment and materials may be required to conduct air sampling and monitoring at hazardous waste sites:

- Camera
- Site logbook
- Clipboard
- Chain of custody records
- Custody seals
- Air sampling worksheets
- Sample labels
- Small screwdriver set
- Aluminum foil
- Extension cords
- Glass cracker
- Multiple plug outlet
- Whirl bags or culture tubes
- Teflon tape
- Calibration devices
- Tygon and/or Teflon[R] tubing
- Surgical gloves
- Lint-free gloves
- Ice
- Sample container

Use the following additional equipment when decontaminating glassware on site:

- Protective equipment (i.e., gloves, splash goggles, etc.)
- Appropriate solvent(s)
- Spray bottles
- Liquinox (soap)
- Paper towels

- Distilled/deionized water
- Five-gallon buckets
- Scrub brushes and bottle brushes

6.0 REAGENTS

Impinger sampling involves using reagents contained in a glass vial to absorb contaminants of concern (for example, NIOSH Method 3500 for formaldehyde uses 1% sodium bisulfite solution). Impinger solutions vary and are method-dependent.

Reagents such as acetone and hexane are required to decontaminate glassware and some air sampling equipment. Decontamination solutions are specified in the Sampling Equipment Decontamination SOP.

7.0 PROCEDURES

7.1 Air Monitoring Design

7.1.1 Initial Surveys

In general, the initial survey is considered to be a relatively rapid screening process for collecting preliminary data at hazardous waste sites. However, initial surveys may require many hours to complete and may consist of more than one entry.

Some information is generally known about the site; therefore, real-time instrumentation for specific compounds (i.e., detector tubes and electrochemical sensors) can be used to identify hot spots. Sufficient data should be obtained with real-time instruments during the initial entry to screen the site for various contaminants. When warranted, intrinsically safe or explosion-proof instruments should be used. An organic vapor analyzer (OVA) is typically used during this survey. These gross measurements may be used on a preliminary basis to (1) determine levels of personal protection, (2) establish site work zones, and (3) map candidate areas for more thorough qualitative and quantitative studies involving air sampling.

In some situations, the information obtained may be sufficient to preclude additional monitoring. Materials detected during the initial survey may call for a more comprehensive evaluation of hazards and analyses for specific compounds. Since site activities and weather conditions change, a continuous program to monitor the ambient atmosphere must be established.

7.1.2 Off-Site Monitoring

Typically, perimeter monitoring with the same instruments employed for on-site monitoring is utilized to determine site boundaries. Because air is a dynamic matrix, physical boundaries like property lines and fences do not necessarily delineate the site boundary or area influenced by a release. Whenever possible, atmospheric hazards in the areas adjacent to the on-site zone should be monitored with direct-reading instruments. Monitoring at the fenceline or at varying locations off site provides useful information regarding pollutant migration. Three to four locations downwind of the source (i.e., plume) at breathing-zone height, provide a basic fingerprint of the plume. Negative instrument readings off site should not be interpreted as the complete absence of airborne toxic substances; rather, they should be considered another piece of information to assist in the preliminary evaluation. The interpretation of negative readings is instrument-dependent. The lack of instrument readings off site should not be interpreted as the complete absence of all airborne toxic substances; rather, it is possible that the particular compound or class of compounds to which the monitoring instrument responds is not present or that the concentration of the compound(s) is below the instrument's detection limit.

7.2 Air Sampling Design

7.2.1 Sampling Plan Design

The goal of air sampling is to accurately assess the impact of a contaminant source(s) on ambient air quality. This impact is expressed in terms of overall average and/or maximum air concentrations for the time period of concern and may be affected by the transport and release of pollutants from both on- and off-site sources. The location of these sources must be taken into account as they impact the selection of sampling locations. Unlike soil and groundwater concentrations, air concentrations at points of interest can easily vary by orders of magnitude over the period of concern. This variability plays a major role in designing an air sampling plan.

Downwind air concentration is determined by the amount of material being released from the site into the air (the emission rate) and by the degree that the contamination is diluted as it is transported. Local meteorology and topography govern downwind dilution. Contaminant emission rates can also be heavily influenced by on-site meteorology and on-site activities. All of these concerns must be incorporated into an air sampling plan.

A sampling strategy can be simple or complex, depending on the sampling program objectives. Programs involving characterization of the pollutant contribution from a single point source tend to be simple, whereas sampling programs investigating fate and transport characteristics of components from diverse sources require a more complex sampling strategy. In addition, resource constraints may affect the complexity of the sampling design.

An optimal sampling strategy accounts for the following site parameters:

- Location of stationary as well as mobile sources
- Analytes of concern
- Analytical detection limit to be achieved
- Rate of release and transport of pollutants from sources
- Availability of space and utilities for operating sampling equipment
- Meteorological monitoring data
- Meteorological conditions in which sampling is to be conducted

The sampling strategy typically requires that the concentration of contaminants at the source or area of concern as well as background contributions be quantified. It is important to establish background levels of contaminants in order to develop a reference point from which to evaluate the source data. Field blanks and lot blanks, as well as various other types of QA/QC samples, can be utilized to determine other sources. The impact of extraneous sources on sampling results can frequently be accounted for by placing samplers upwind, downwind and crosswind from the subject source. The analytical data from these different sampling locations may be compared to determine statistical differences.

7.2.2 Sampling Objectives

The objectives of the sampling must be determined prior to developing the sampling plan. Does the sampling plan verify adequate levels of protection for on-site personnel, or address potential off-site impacts associated with the site or with site activities? In addition, the assumptions associated with the sampling program must be defined. These assumptions include whether the sampling is to take place under "typical," "worst case," or "one-time" conditions. If the conditions present at the time of sampling are different from those assumed during the development of the sampling plan, then quality of the data collected may be affected. The following definitions have been established:

- Typical: routine daily sampling or routine scheduled sampling at pre-established locations.

- Worst case: sampling conducted under the worst meteorological and/or site conditions which would result in elevated ambient concentrations.

- One-time: only one chance is given to collect a sample without regard to time or conditions.

Qualitative data acquired under these conditions are usually applicable only to the time period during which the data were collected and may not provide accurate information to be used in estimating the magnitude of an air impact during other periods or over a long time interval.

The sampling objectives also dictate the detection limits. Sampling methods for airborne contaminants will depend upon the nature and state (solid, liquid or gas) of the contaminant. Gases and vapors may be collected in aqueous media or adsorbents, in molecular sieves, or in suitable containers. Particulates are collected by filters or impactors. The volume of sample to be collected is dependent upon an estimate of the contaminant concentration in the air, the sensitivity of the analytical method, and the standard or desired detection limit. A sufficient amount of sample must be collected to achieve the desired detection limit without interference from other contaminants. In addition, the selected method must be able to detect the target compound(s).

7.2.3 Location and Number of Individual Sampling Points

Choose the number and location of sampling points according to the variability, or sensitivity, of the sampling and analytical methods being utilized, the variability of contaminant concentration over time at the site, the level of precision required and costlimitations. In addition, determine the number of locations and placement of samplers by considering the nature of the response, local terrain, meteorological conditions, location of the site (with respect to other conflicting background sources), size of the site, and the number, size, and relative proximity of separate on-site emission sources and upwind sources. The following are several considerations for sampler placement:

- Location of potential on-site emission sources, as identified from the review of site background information or from preliminary on-site inspections.

- Location of potential off-site emission sources upwind of the sampling location(s). Review local wind patterns to determine the location of off-site sources relative to wind direction.

- Topographic features that affect the dispersion and transport of airborne toxic constituents.

Avoid natural obstructions when choosing air sampling station locations, and account for channelization around those obstructions.

- Large water bodies, which affect atmospheric stability and the dispersion of air contaminants.

- Roadways (dirt or paved), which may generate dust that could mask site contaminants.

- Vegetation, such as trees and shrubs, which stabilizes soil and retards subsurface contaminants from becoming airborne. It also affects air flow and scrubs some contaminants from the air. Sometimes thick vegetation can make an otherwise ideal air monitoring location inaccessible.

Consider the duration of sampling activities when choosing the location and number of samples to be collected. For example, if the sampling period is limited to a few hours, one or two upwind and several downwind samples would typically be adequate, especially around major emission sources.

A short-term monitoring program ranges from several days to a few weeks and generally includes gathering data for site assessments, removal actions, and source determination data (for further modeling). Activities involved in a short-term sampling strategy must make the most of the limited possibilities for data collection. Consider moving upwind/downwind locations daily based on National Oceanic and Atmospheric Administration (NOAA) weather forecasts. Weather monitoring becomes critical where complex terrain and local meteorological effects frequently change wind direction. Often, a number of alternatives can fulfill the same objective.

Prevailing winds running the length of a valley usually require a minimum number of sampler locations; however, a complex valley may require more sampler locations to account for the wide variety of winds. Ocean/lake effects may require a radical plan to collect enough samples to reach a low detection limit. Two sets of samplers may be placed next to each other: one set would be activated during the sea breeze while the other set is turned off, and vice versa when there is no sea breeze. After the sampling event, the respective upwind and downwind samples would be combined. Another alternative for sampling near a large body of water may be to use automatic, wind-vector-operated samplers, which turn the sampler on only when the wind comes from a specified vector. At sites located on hillsides, wind will move down a valley and produce an upward fetch at the same time. Sampling locations may have to ring the site to measure the wind's impact.

Off-site sources may affect on-site monitoring. In this case, on-site meteorological data, concurrent with sampling data, is essential to interpreting the acquired data. Also, additional upwind sampling sites may be needed to fully characterize ambient background contaminant levels. Multiple off-site sources may require several monitoring locations, but if the sources are at a sufficient distance, only one monitoring location is needed.

Topography and weather are not the only factors in sampler location; the sampling sites must be secure from vandals and mishap. Secure all sampling locations to maintain chain of custody, and to prevent tampering with samples or loss of sampling units. High-volume sampling methods often require the use of 110 VAC electric power. When portable generators are used, the power quality may affect sampler operation. Also, be aware that the generators themselves could be a potential pollution source if their placement is not carefully considered.

Air quality dispersion models can be used to place samplers. The models incorporate source information, surrounding topography, and meteorological data to predict the general distance and directions of maximum ambient concentrations. Modeling results should be used to select sampling locations in areas of maximum pollutant concentrations.

7.2.4 Time, Duration and Frequency of Sampling Events

After choosing appropriate sampling or monitoring locations, determine the sampling frequency and the number of samples to be collected. The time of day, duration and frequency of sampling events is governed by:

- The effects of site activities and meteorology on emission rates
- The diurnal effect of the meteorology on downwind dispersion
- The time period(s) of concern as defined by the objective
- The variability in the impact from other non-site-related sources
- If defined, the degree of confidence needed for either the mean or maximum downwind concentrations observed
- The precision requirements for single measurements
- Cost and other logistical considerations

The duration of the removal action and the number of hours per day that site work is conducted determine the time, duration, and frequency of samples. Short-term sampling programs may require daily sampling, while long-term programs may require 24-hour sampling every sixth or twelfth day. If the site will be undergoing removal activities 24 hours a day, continuous air sampling may be warranted. However, if the site activities will be conducted for only eight hours a day, and there are no emissions likely to occur during the remaining 16 hours, then sampling would be appropriate prior to the start of daily activities, would continue during operations, and end at the conclusion of the daily activities. An off-peak sample collection can ensure that emissions are not persisting after the conclusion of daily cleanup activities. For some sites, emissions are still a factor several hours after daily site activities have been completed. Because of the typically decreased downwind dispersion in the evening, higher downwind concentrations than were present during daytime site activities may be detected. For sites where this is possible, the sampling duration needs to be lengthened accordingly.

Sampling duration and flow rate dictate the volume of air collected, and to a major degree, the detection limit. The analytical method selected will provide a reference to flow rate and volume. Flow rates are limited to the capacity of the pumps being employed and the contact time required by the collection media.

The duration or period of air sampling is commonly divided into two categories (1) samples collected over a brief time period are referred to as "instantaneous" or "grab" samples and are usually collected in less than five minutes and (2) average or integrated samples are collected over a significantly longer period of time. Integrated samples provide an average concentration over the entire sampling period. Integrated samples are not suited to determining cyclical releases of contaminants because periodic or cyclical events are averaged out by the proportionally long sampling duration.

Air quality dispersion models can predict the maximum air contaminant concentration expected from a source. The meteorological and site conditions expected to cause the highest concentration are known as worst-case conditions and can be identified by analyzing the modeling results. Depending upon the objective, one may sample when the model predicts worst-case conditions will exist.

7.2.5 Meteorological and Physical/Chemical Considerations

A meteorological monitoring program is an integral part of site monitoring activities. Meteorological data, which define local terrain impacts on air flow paths, are needed to interpret air concentration data. Meteorological data may be available from an existing station located near the site (i.e., at a local airport), otherwise a station should be set up at the site. This data will document the degree that samples actually were downwind and verify whether other worst-case assumptions were met. Meteorological parameters to be monitored are, at a minimum, wind speed, wind direction, and sigma theta (which is the horizontal wind direction standard deviation and an indicator of atmospheric stability). The remaining parameters primarily affect the amount of a contaminant available in the air.

- Wind Speed

  When the contaminant of concern is a particulate, wind speed is critical in determining whether the particulate will become airborne, the quantity of the particulate that becomes airborne, and the distance the particulate will travel from the source. Wind speed also contributes to the volatilization of contaminants from liquid sources.

- Wind Direction

  Wind direction highly influences the path of airborne contaminants. In addition, variations in wind direction increase the dispersion of pollutants from a given source.

- Atmospheric Stability

  Atmospheric stability refers to the degree to which the atmosphere tends to dampen vertical and horizontal motion. Stable atmospheric conditions (i.e., evenings) result in low dispersion, and unstable atmospheric conditions (i.e., hot sunny days) result in higher dispersion.

- Temperature

  Higher temperatures increase the rate of volatilization of organic and some inorganic compounds and affect the initial rise of gaseous or vapor contaminants. Therefore, worst-case emission of volatiles and semivolatiles occurs at the hottest time of day, or on the hottest day.

- Humidity

  High humidity affects water-soluble chemicals and particulates. Humid conditions may dictate the sampling media used to collect the air sample, or limit the volume of air sampled and thereby increase the detection limit.

- Atmospheric Pressure

  Migration of landfill gases through the landfill surface and through surrounding soils are governed by changes in atmospheric pressure. Atmospheric pressure will influence upward migration of gaseous contaminants from shallow aquifers into the basements of overlying structures.

In many cases, the transport and dispersion of air pollutants is complicated by local meteorology. Normal diurnal variations (i.e., temperature inversions) affect dispersion of airborne contaminants. Terrain features can enhance or create air inversions and can also influence the path and speed of air flow, complicating transport and dispersion patterns.

The chemical characteristics of a contaminant (i.e., molecular weight, physical state, vapor pressure, aerodynamic size, temperature, reactive compounds, and photodegradation) affects its behavior and can influence the method used to sample and analyze it.

8.0 CALCULATIONS

Volume is obtained by multiplying the sample time in minutes by the flow rate. Sample volume should be indicated on the chain of custody record. Adjustments for temperature and pressure differences may be required.

Results are usually provided in parts per million (ppm), parts per billion (ppb), milligrams per cubic meter (mg/m^3) or micrograms per cubic meter ($\mu g/m^3$).

Refer to the analytical method or regulatory guidelines for other applicable calculations.

9.0 QUALITYASSURANCE/ QUALITY CONTROL

The manufacturer's instructions should be reviewed prior to instrument use. Instruments must be utilized in accordance with manufacturer's instructions. Equipment checkout and calibration activities must occur prior to and after monitoring and sampling and must be documented.

9.1 QA/QC Samples

QA/QC samples provide information on the variability and usability of environmental sample results. Various QA/QC samples may be collected to detect error. QA/QC samples are submitted with the field samples for analysis to aid in identifying the origin of analytical discrepancies; then a determination can be made as to how the analytical results should be used. Collocated samples, background samples, field blanks, and lot blanks are the most commonly collected QA/QC field samples. Performance evaluation (PE) samples and matrix spikes provide additional measures of data QA/QC control. QA/QC results may suggest the need for modifying sample collection, preparation, handling, or analytical procedures if the resultant data do not meet site-specific QA or data quality objectives.

9.2 Sample Documentation

All sample and monitoring activities should be documented legibly, in ink. Any corrections or revisions should be made by lining through the incorrect entry and by initialing the error. All samples must be recorded on an Air Sampling Worksheet. A chain of custody record must be maintained from the time a sample is taken to the final deposition of the sample. Custody seals demonstrate that a sample container has not been opened or tampered with during transport or storage of samples.

10.0 DATA VALIDATION

Results for QA/QC samples should be evaluated for contamination. This information should be utilized to qualify the environmental sample results accordingly with data quality objectives.

11.0 HEALTH AND SAFETY

Personal protection equipment (PPE) requirements identified in federal and/or state regulations and 29 Code of Federal Regulations (CFR) 1910.120 for hazardous waste site work must be followed.

The majority of physical precautions involved in air sampling are related to the contaminant sampled. Attention should be given when sampling in potentially explosive, flammable or acidic atmospheres. On rare occasions, the collection media may be hazardous; for example, in the instance where an acidic or basic solution is utilized in an impinger.

When working with potentially hazardous materials, follow U.S. EPA, OSHA and corporate health and safety procedures.

12.0 REFERENCES

(1) U.S. EPA. *Air Superfund National Technical Guidance Series. Volume I. Application of Air Pathway Analyses for Superfund Activities.* EPA/450/1-89/001.

(2) U.S. EPA. *Air Superfund National Technical Guidance Series. Volume II. Estimation of Baseline Air Emissions at Superfund Sites.* EPA/450/1-89/002.

(3) U.S. EPA. *Air Superfund National Technical Guidance Series. Volume III.*

Estimations of Air Emissions from Cleanup Activities at Superfund Sites. EPA/450/1-89/003.

(4) U.S. EPA. *Air Superfund National Technical Guidance Series. Volume IV. Procedures for Dispersion Air Modeling and Air Monitoring for Superfund Air Pathway Analysis*. EPA/450/1-89/004.

(5) *Guide to Portable Instruments for Assessing Airborne Pollutants Arising from Hazardous Wastes*, International Organization of Legal Metrology (OIML) U.S. National Working Group (NWG) for OIML, American Conference of Governmental Industrial Hygienists, Cincinnati, OH

(6) NIOSH. *Manual of Analytical Methods, Second Edition. Volumes 1-7.* U.S. Department of Health and Human Services Publication No. 84-100.

NIOSH. *Manual of Analytical Methods*, February 1984. U.S. Department of Health and Human Services Publication No. 84-100.

(7) ASTM. 1990. *Annual Book of Standards, Volume 11.03.*

(8) Riggin, R.M. *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air*. EPA/600/4-84/041.

(9) Winberry, W.T. *Supplement to U.S. EPA/600/4-84/041: Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air.* EPA/600/4-87/006.

(10) OSHA. *Analytical Methods Manual, Second Edition. Part 1, Organic Substances,* January 1990. *Part 2, Inorganic Substances* August 1991.

(11) Patty, F.A., *Industrial Hygiene and Toxicology, Third Edition*, John Wiley and Sons, Inc., New York, NY.

(12) *Air Sampling Instruments for Evaluation of Atmospheric Contaminants, Seventh Edition*, 1989, American Conference of Governmental Industrial Hygienists, Cincinnati, OH

BIBLIOGRAPHY

Removal Program Representative Sampling Guidance, Volume 2: Air, Environmental Response Branch, Emergency Response Division, Office of Emergency and Remedial Response, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, April 1992, Interim Final.

APPENDIX A

PORTABLE SCREENING DEVICES

Where possible, a datalogger should be used to minimize the length of time required for site personnel to be in a potentially contaminated area. Datalogger cable is available from manufacturers for linear output instruments and some nonlinear output instruments. U.S. EPA ERT/REAC has output cables for organic vapor analyzers (i.e., HNU and OVA), toxic gas analyzers (i.e., monitox) and real-time aerosol monitors (i.e., RAM and miniram).

- Total Hydrocarbon Analyzers

  Total hydrocarbon analyzers used to detect a variety of volatile organic compounds (VOCs) at hazardous waste sites principally employ either a photoionization detector (PID) or a flame ionization detector (FID). Compounds are ionized by a flame or an ultraviolet lamp. PIDs depend on the ionization potential of the compounds. PIDs are sensitive to aromatic and olefinic (unsaturated) compounds such as benzene, toluene, styrene, xylenes, and acetylene. Greater selectivity is possible by using low-voltage lamps. The ionization potential of individual compounds can be found in the NIOSH Pocket Guide to Chemical Hazards. These instruments are not compound-specific and are typically used as screening instruments. FIDs are sensitive to volatile organic vapor compounds such as methane, propanol, benzene and toluene. They respond poorly to organic compounds lacking hydrocarbon characteristics.

- Oxygen and Combustible Gas Indicators

  Combustible Gas Indicators (CGIs) provide efficient and reliable methods to test for potentially explosive atmospheres. CGI meters measure the concentration of a flammable vapor or gas in air and present these measurements as a percentage of the lower explosive limit (LEL).

The measurements are temperature-dependent. The property of the calibration gas determines sensitivity. LELs for individual compounds can be found in the NIOSH Pocket Guide to Chemical Hazards. If readings approach or exceed 10% of the LEL, extreme caution should be exercised in continuing the investigation. If readings approach or exceed 25% LEL, personnel should be withdrawn immediately.

CGIs typically house an electrochemical sensor to determine the oxygen concentration in ambient air. Normally, air contains approximately 20.9% oxygen by volume. Oxygen measurements are of particular importance for work in enclosed spaces, low-lying areas, or in the vicinity of accidents that have produced heavier-than-air vapors which could displace ambient air. The meters are calibrated for sea level and may indicate a false negative (i.e, O_2 content) at higher altitudes. Since the air has been displaced by other substances, these oxygen-deficient areas are also prime locations for taking additional organic vapor and combustible gas measurements. Oxygen-enriched atmospheres increase the potential for fires by their ability to contribute to combustion or to chemically react with flammable compounds and promote auto-ignition.

- Toxic Atmosphere Analyzers

  The toxic atmosphere analyzer is a compound-specific instrument, designed and calibrated to identify and quantify a specific compound or class of compounds in either gaseous or vapor form. Cross-sensitivity to air pollutants not of interest may be lead to erroneous results.

  U.S. EPA/ERT has the following toxic atmosphere analyzers: carbon monoxide, phosgene, nitrous oxide, hydrogen cyanide, sulfur dioxide, hydrogen sulfide, and chlorine gas.

- Aerosol/Particulate Monitors

A Real-Time Aerosol/Particulate Monitor (RAM) displays readings for total particulates. The instrument employs a pulse light emitting diode which generates a narrow band emission in conjunction with a photovoltaic cell to detect light scattered from particulates.

The U.S. EPA/ERT uses the RAM when the contaminant of concern is associated with particulates, and when responding to fires involving hazardous materials, to identify plume levels. The instrument is very useful in determining the presence of a plume when it is not visible. The U.S. EPA/ERT typically uses RAMs on tripods to obtain particulate concentrations at the breathing zone level. Personal dataloggers are used with the RAMs to document minimum, average and maximum concentrations. This provides real-time data without requiring those in personal protective equipment to be constantly present in the plume.

- Chemical Detector Tubes (Colorimetric Tubes)

A chemical detector tube is a hollow, tube-shaped, glass body containing one or more layers of chemically impregnated inert material. To use, the fused ends are broken off and a manufacturer-specified volume of air is drawn through the tube with a pump to achieve a given detection limit. The chemicals contained within the packing material undergo a chemical reaction with the airborne pollutant present, producing a color change during the intake of each pump stroke. The concentration of a pollutant is indicated by the length of discoloration on a calibrated scale printed on the detector tube.

- Radiation Meters

Radiation meters determine the presence and level of radiation. The meters use a gas or solid ion detection media which becomes ionized when radiation is present. The meters are normally calibrated to one probe. Meters that detect alpha, beta, and gamma radiation are available.

- Gold Film (Hydrogen Sulfide and Mercury Vapor) Monitors

  Hydrogen sulfide (H_2S) and Mercury (Hg) monitors operate on the principle that electric resistivity increases across a gold film as a function of H_2S and Hg concentration. The monitors provide rapid and relatively low detection limits for H_2S and Hg in air. After extensive sampling periods or high concentrations of H_2S and Hg, the gold film must be heated to remove contamination and return the monitor to its original sensitivity.

- Infrared Detectors

  Infrared detectors such as the Miniature Infrared Analyzer (MIRAN) use infrared (IR) absorption as a function of specific compounds. MIRAN instruments apply to situations where the contaminants are identified but concentrations are not. MIRAN instruments generally require AC power.

SPECIALIZED ANALYTICAL INSTRUMENTS

The continuous monitors described above provide qualitative measurement of air contaminants. Quantitative measurements in the field can be obtained using more sophisticated instruments, such as portable Gas Chromatographs, to analyze grab samples.

- Direct Air Sampling Portable Gas Chromatographs (GCs)

  Portable GCs use gas chromatography to identify and quantify compounds. The time it takes for a compound to move through a chromatographic column is a function of that specific compound or group of compounds. A trained technician with knowledge of the range of expected concentrations of compounds can utilize a portable GC in the field to analyze grab samples. GCs generally require AC power and shelter to operate. This method is limited by its reliance on a short-term grab sample to be representative of the air quality at a site.

- Remote Optical Sensing

  This technique, also referred to as long-path or open-path monitoring, involves transmitting either an infrared or ultraviolet light beam across a long open path and measuring the absorbance at specific wavelengths. The technique is capable of analyzing any preselected organic or inorganic volatile compound that can be resolved from compounds naturally occurring in ambient air. Current projected removal applications include perimeter monitoring during site cleanups and measurement of emission source strengths during site assessments.

- TAGA Direct Air Sampling Mass Spectrometer/Mass Spectrometer

  The Trace Atmospheric Gas Analyzer (TAGA), which is operated by the U.S. EPA/ERT, is capable of real-time detection of preselected organic compounds at low parts-per-billion concentrations. The instrument has been successfully used by the U.S. EPA/ERT for isolating individual emission plumes and tracking those plumes back to their sources.

APPENDIX B

Air Sampling Equipment and Media/Devices

AIR SAMPLING EQUIPMENT

- High-Volume, Total Suspended Particulate (TSP) Samplers

  High-volume TSP samplers collect all suspended particles by drawing air across an 8- by 10-inch glass-quartz filter. The sample rate is adjusted to 40 cubic feet per minute (CFM), or 1134 liters per minute (L/min), and it is held constant by a flow controller over the sample period. The mass of TSPs can be determined by weighing the filter before and after sampling. The composition of the filter varies according to the analytical method and the detection limit required.

- PM-10 Samplers

  PM-10 samplers collect particulates with a diameter of 10 microns or less from ambient air. Particulates of this size represent the respirable fraction, and thus are of special significance. PM-10 samplers can be high-volume or low-volume. The high-volume sampler operates in the same manner as the TSP sampler at a constant flow rate of 40 CFM; it draws the sample through a special impactor head which collects particulates of 10 microns or less. The particulate is collected on an 8- by 10-inch filter. The low-volume sampler operates at a rate of approximately 17 L/min. The flow must remain constant through the impactor head to maintain the 10-micron cut-off point. The low-volume PM-10 collects the sample on 37-mm Teflon filters.

- High-Volume PS-1 Samplers

  High-volume PS-1 samplers draw a sample through polyurethane foam (PUF) or a combination foam and XAD-2 resin plug, and a glass quartz filter at a rate of 5-10 CFM (144 to 282 L/min). This system is excellent for measuring low concentrations of semivolatiles, PCBs, pesticides, or chlorinated dioxins in ambient air.

- Area Sampling Pumps

  These pumps provide flow-rate ranges of 2-20 L/min and have a telescopic sampling mast with the sampling train. Because of the higher volume, this pump is suitable for sampling low concentrations of airborne contaminants (i.e., asbestos sampling). These pumps are also used for metals, pesticides and PAH sampling which require large sample volumes.

- Personal Sampling Pumps

  Personal sampling pumps are reliable portable sampling devices that draw air samples through a number of sampling media including resin tubes, impingers, and filters. Flow rates are usually adjustable from 0.1 to 4 L/min (or 0.01 to .75 L/min with a restrictive orifice) and can remain constant for up to 8 hours on one battery charge or continuously with an AC charger/converter.

- Canister Samplers

  Evacuated canister sampling systems use the pressure differential between the evacuated canister and ambient pressure to bleed air into the canister. The sample is bled into the canister at a constant rate over the sampling period using a critical orifice, a mechanically compensated regulator, or a mass flow control
  device until the canister is near atmospheric pressure.

  Pressure canister sampling systems use a pump to push air into the canister. To maintain a higher, more controlled flow, the pump typically controls the pressure differential across a critical orifice at the inlet of the canister, resulting in a pressurized canister at the completion of sampling.

AIR SAMPLING MEDIA/DEVICES

If possible, before employing a specific sampling method, consult the laboratory that will conduct the analyses. Many of the methods can be modified to provide better results or a wider range of results.

- Summa[R] Canisters

  Summa canisters are highly polished passivated stainless steel cylinders. The Summa polishing process brings chrome and nickel to the surface of the canisters, which results in an inert surface. This surface restricts adsorption or reactions that occur on the canister's inner surface after collection. At the site, the canister is either placed in a sampler to control sample collection rate, or opened to collect a grab sample. Samples can be collected by allowing air to bleed into or be pumped into the canister. U.S. EPA/ERT uses 6-liter Summa canisters for VOC and permanent gas analysis.

- Passive Dosimeters

  Passive dosimeters are clip-on vapor monitors (samplers) in which the diffused contaminants are absorbed on specially prepared active surfaces. Industrial hygienists commonly use dosimeters to obtain time-weighted averages or concentrations of chemical vapors, as they can trap over 130 organic compounds. Selective dosimeters have also been developed for a number of chemicals including formaldehyde, ethylene oxide, hydrogen sulfide, mercury vapor, nitrogen dioxide, sulfur dioxide, and ozone. Dosimeters must be sent to a laboratory for analysis.

- Polyurethane Foam (PUF)

  PUF is a sorbent used with a glass filter for the collection of semivolatile organic compounds such as pesticides, PCBs, chlorinated dioxins and furans, and PAHs. Fewer artifacts (chemical changes that occur to collected compounds) are produced than with some other solid sorbents. PUF is used with the PS-1 sampler and U.S. EPA Method TO13. PUF can also be used with personal sampling pumps when sampling for PAHs using the Lewis/McCloud method. Breakthrough of the more volatile PCBs and PAHs may occur when using PUF.

- Sampling Bags (Tedlar[R])

  Sampling bags, like canisters, transport air samples to the laboratory for analysis. Samples are generally pumped into the bags, but sometimes a lung system is used, in which a pump creates a vacuum around the bag in a vacuum box. Then the sample flows from a source into the bag. This method is used for VOCs, fixed gases (CO_2, O_2 and N_2) and methane.

- Impingers

  An impinger allows an air sample to be bubbled through a solution, which collects a specific contaminant by either chemical reaction or absorption. For long sampling periods, the impinger may need to be kept in an ice bath to prevent the solution from evaporating during sampling. The sample is drawn through the impinger by using a sampling pump or more elaborate sampling trains with multiple impingers.

- Sorbent Tubes/Cartridges

  A variety of sampling media are available in sorbent tubes, which are used primarily for industrial hygiene. A few examples are carbon cartridges, carbon molecular sieves, Tenax tubes and tube containing the XAD-2 polymer. Depending upon the sorbent material, tubes can be analyzed using either a solvent extraction or thermal desorption. The former technique uses standard laboratory equipment and allows for multiple analyses of the same sample. The latter technique requires special, but readily available, laboratory equipment and allows only one analysis per sample. In addition, thermal desorption typically allows for lower detection limits by two or more orders of magnitude. Whenever sorbent tubes are being used for thermal desorption, they should be certified as "clean" by the laboratory doing the analysis.

Thermally Desorbed Media

During thermal desorption, high-temperature gas streams are used to remove the compounds collected on a sorbent medium. The gas stream is injected and often cryofocused into an analytical instrument, such as a GC, for compound analysis:

- Tenax Tubes

  Tenax tubes are made from commercially available polymer (p-phenylene oxide) packed in glass or stainless steel tubes through which air samples are drawn or sometimes pumped. These tubes are used in U.S. EPA Method TO1 and VOST for volatile nonpolar organic, some polar organic, and some of the more volatile semivolatile organics. Tenax is not appropriate for many of the highly volatile organics (with vapor pressure greater than approximately 200 mm Hg).

- Carbonized Polymers

  The carbonized molecular sieve (CMS), a carbonized polymer, is a commercially available, carbon sorbent packed in stainless-steel sampling tubes through which air samples are drawn or sometimes pumped. These are used in U.S. EPA Method TO2 for highly volatile nonpolar compounds which have low-breakthrough volumes on other sorbents. When high-thermal desorption temperatures are used with CMS, more variability in analysis may occur than with other sorbents.

- Mixed Sorbent Tubes

  Sorbent tubes can contain two type of sorbents. Combining the advantages of each sorbent into one tube increases the possible types of compounds to be sampled. The combination of two sorbents can also reduce the chance that highly volatile compounds will break through the sorbent media. An example of a mixed sorbent tube is the combination of Tenax and charcoal with a carbonized molecular sieve. A potential problem with mixed sorbent tubes is the breakthrough of a compound from an earlier sorbent to a later sorbent from which it cannot be desorbed.

Solvent-Extracted Media

Solvent-extracted media use the principle of chemical extraction to remove compounds collected on a sorbent media. The chemical solvent is injected into an instrument, such as a GC, for analysis of compounds. Examples of solvent-extracted media follow:

- Chemically Treated Silica Gel

  Silica gel is a sorbent which can be treated with various chemicals. The chemically treated silica gel can then be used to sample for specific compounds in air. Examples include the DNPH-coated silica gel cartridge used with U.S. EPA Method TO11.

- XAD-2 Polymers

  XAD-2 polymers usually are placed in tubes, custom-packed sandwich-style with polyurethane foam, and prepared for use with U.S. EPA Method TO13 or the semi-VOST method. The polymers are used for the collection of semivolatile polar and nonpolar organic compounds. The compounds collected on the XAD-2 polymer are chemically extracted for analysis.

- Charcoal Cartridges

  Charcoal cartridges, consisting of primary and backup sections, trap compounds by adsorption. Ambient air is drawn through them so that the backup section verifies that breakthrough of the analytes on the first section did not occur, and the sample collection was therefore quantitative. Quantitative sample collection is evident by the presence of target chemicals on the first charcoal section and the absence on the second section. Next, the adsorbed compounds must be eluted, usually with a solvent extraction, and analyzed by GC with a detector, such as a Mass Spectrometer (MS).

- Tenax Tubes

  Cartridges are used in OSHA and NIOSH methods in a manner similar to charcoal cartridges but typically for less volatile compounds.

Particulate Filters

Particulate filters are used by having a sampling pump pass air through them. The filter collects the particulates present in the air and is then analyzed for particulate mass or chemical or radiological composition. Particulate filters are made from different materials which are described below.

- Mixed Cellulose Ester (MCE)

  MCE is manufactured from mixed esters of cellulose which are a blend of nitro-cellulose and cellulose acetate. MCE filters are used often for particulate sampling.

- Glass Fiber

  Glass fiber is manufactured from glass fibers without a binder. Particulate filters with glass fiber provide high flow rates, wet strength, and high, solid holding capacity. Generally, the filters are used for gravimetric analysis of particulates.

- Polyvinyl Chloride

  Particulate filters with polyvinyl chloride are resistant to concentrated acids and alkalis. Their low moisture pickup and light tare weight make them ideal for gravimetric analysis.

- Teflon

  Teflon is manufactured from polytetrafluorethylene (PTFE). Particulate filters with Teflon are easy to handle and exceptionally durable. Teflon filters are used for metal collection.

- Silver

  Particulate filters manufactured from pure silver have high collection efficiency and uniform pore size. These filters are used for mercury collection and analysis.

- Cellulose

  Particulate filters with cellulose contain less than 0.01% ash. These filters are used to collect particulates.

CHARCOAL TUBE SAMPLING IN AMBIENT AIR

SOP#: 2103
DATE: 10/24/94
REV. #: 0.0

1.0 SCOPE AND APPLICATION

The purpose of the Standard Operating Procedure (SOP) is to define the procedure for charcoal tube sampling which is utilized to identify specific contaminants in ambient air. The greatest selectivity of activated charcoal is towards non-polar organic solvent vapors, (e.g., carbon tetrachloride, chlorobenzene and toluene). Organic compounds that are gaseous at room temperature, reactive, polar, or oxygenated (aldehyde alcohols and some ketones), are either not adsorbed (relatively early breakthrough), or inefficiently desorbed.

These are standard (i.e., typically applicable) operating procedures which may be varied or changed as required, dependent upon site conditions, equipment limitations or limitations imposed by the procedure. In all instances, the ultimate procedures employed should be documented and associated with the final report.

Mention of trade names or commercial products does not constitute U.S. Environmental Protection Agency (U.S. EPA) endorsement or recommendation for use.

2.0 METHOD SUMMARY

Charcoal tube sampling is performed by drawing a known volume of air through a charcoal adsorption tube. As air is drawn through the tube during sampling, gases and vapors adsorb onto the surface of the charcoal. After sampling, the tubes are delivered to the laboratory for analysis.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Charcoal used for sampling is housed in a glass tube that has been flame sealed. Charcoal tubes most often used contain 150 mg or 600 mg of charcoal. The smaller 150-mg tube is 7-cm long with a 4-mm inner diameter (ID) and a 6-mm outer diameter (OD) containing two sections of 20/40 mesh activated charcoal separated by urethane foam. The adsorbing section contains 100-mg of charcoal, the backup section 50-mg of charcoal. The larger 600-mg tube is 11-cm long with a 6-mm ID and a 8-mm OD containing two sections of 20/40 mesh activated charcoal separated by urethane foam. The adsorbing section contains 400 mg of charcoal, the backup section contains 200-mg of charcoal. A greater volume of air can be drawn through the larger tube thereby providing a greater sensitivity.

To preserve and store samples:

1. Place plastic caps on the charcoal tube ends.
2. Place the sample in a whirl bag. If collocated samples have been collected, place both tubes in one whirl bag.
3. If the sample tube must be stored for more than a week, refrigeration is recommended. Maximum recommended holding time is two weeks.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

Low sampling flow rates, and high temperature and humidity may cause a decrease in the adsorption capacity of activated carbon. Contaminants from the front portion of the tube may migrate to the back portion of the tube. Refrigeration may minimize this migration.

5.0 EQUIPMENT

5.1 Equipment List

- Personal Sampling Pump
- Dowel Rods
- Single or Dual Rotameter (with stand and desired precalibrated flow rate)
- Charcoal Tubes (600 mg or 150 mg)

- Tygon Tubing (for attaching the tube holder system to the suction side of the pump)
- Sleeves (or support tubes to hold tubes in place)
- Single or Dual Manifold Flow Controller
- Tube Holder End (to support and seal the sampling tube within the plastic housing)
- Glass Tube Cracker
- Resealable Bags
- Whirl Bags
- Plastic End Caps
- Air Sampling Worksheets and Sample Labels
- Chain of Custody Records
- Screwdriver Set

5.2 Equipment Source

Tubes are commercially available from SKC, Inc. and from Mine Safety Appliance Co., both of Pittsburgh, Pennsylvania.

SKC: 1-800-752-8472
Mine Safety Appliance Co.: 1-800-MSA-2222

6.0 REAGENTS

This section is not applicable to this SOP.

7.0 PROCEDURES

7.1 Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and the types and amounts of equipment and supplies needed.

2. Obtain and organize the necessary sampling and monitoring equipment.

3. Decontaminate or pre-clean equipment, and ensure that it is in working order. Precalibrate sampling pumps as described in Section 7.2.

4. Prepare scheduling and coordinate with staff, client, and regulatory agency, if appropriate.

5. Perform a general site survey prior to site entry, in accordance with the site specific Health and Safety Plan.

6. Use stakes, flagging tape, or other appropriate means to identify and mark all sampling locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions.

7.2 Calibration Procedures

To save time in the field, sampling pumps can be precalibrated in the office prior to arriving at the site. The calibration must be checked in the field prior to, and upon completion of sampling.

1. Assemble the calibration train as shown in Figure 1 (Appendix A), using a rotameter, sampling pump, manifold (only if the desired flow rate is below 750 cc/min), a tube holder system (sleeve and tube holder end), and a calibration tube. The calibration tube is a representative tube from the same lot of tubes that is used for sampling.

2. Turn on the pump and adjust the flow using the flow adjust mechanism on the manifold (if used) or on the pump itself until the float ball on the rotameter is aligned with the rotameter's precalibrated flow rate value. A sticker on the rotameter should indicate this value.

3. Affix a sticker to the manifold (if used) and pump indicating the precalibrated flow rate and sampling media.

4. Remove the calibration tube from the sleeve. The pump and manifold (if used) are calibrated as a unit and should not be separated until the samples have been collected.

7.3 Field Operation

1. Mobilize to the clean zone and calibrate the appropriate number of sampling pumps as described in Section 7.2. If the pumps were precalibrated, the calibration should be checked in the same manner. Fine tuning of the flow may be required.

2. Mobilize to the sampling location.

3. Crack the charcoal tube ends using a glass

tube cracker.

4. Insert the charcoal tube in the sleeve with arrow pointing in the direction of air flow (the smaller section is used for a backup and is positioned nearest the sampling pump).

5. Screw the tip onto the sleeve so the charcoal tube is held in place.

6. Attach the sleeve(s) to a single or double manifold. At higher flow rates (>750 cc/min), charcoal tubes can run straight without a manifold.

7. To set up the sampling train, attach one end of the Tygon tubing (approx. 2 foot) to the tip of the sleeve or manifold. Attach the other end of the tubing to the inlet plug on the pump, Figure 2 (Appendix A). Refer to Figures 3 and 4 (Appendix A), respectively, for illustrations of sampling trains without a manifold and with a dual manifold (for collocated samples).

8. Adjust time on the pump to the required sample time.

9. Place the charcoal tube in a position free from obstruction on a dowel rod or stand.

10. Record weather data (e.g., ambient temperature, barometric pressure, relative humidity, and wind direction) on the Air Sampling Worksheet or in the logbook.

11. Turn on the pump.

12. After the pump has run the full time, check the fault button to determine if the pump ran for the scheduled time.

13. Verify calibration by connecting a rotameter with Tygon tubing and turning on the pump. Record the final flow rate on the Air Sampling Worksheet.

7.4 Post Operation Procedures

1. Record the sampling time on the Air Sampling Worksheet.

2. Remove the charcoal tube from the sleeve.

3. Cap charcoal tubes with plastic caps immediately after sampling. Never use rubber caps.

4. Place the sample in a whirl bag labeled with

sample ID#, total volume, and required analysis. If collocated samples have been collected, place each tube in a separate whirl bag and assign a unique sample ID # to each tube.

5. Indicate all applicable information on the Air Sampling Worksheet (e.g., sample volume, ID #, location, date, and weather parameters).

6. If the sample tube must be stored for more than a week, refrigeration is recommended.

7. Prepare samples, including QC samples, for transport by packing them in a shipping container with bubble wrap or styrofoam pieces. Complete a Chain of Custody record in accordance with appropriate Chain of Custody Procedures.

The following methods are typically used for the analysis of charcoal tubes: NIOSH Methods[1,2,3] 1501, Aromatic Hydrocarbons; 1500, Hydrocarbons BP 36°-126°C; and 1003, Halogenated Hydrocarbons. Other analytical parameters may be required. The appropriate analytical methodology should be determined prior to field activities.

8.0 CALCULATIONS

The total volume of a sample is calculated by multiplying the total sample time by the flow rate. The total volume for each sample should be indicated on the Chain of Custody record.

9.0 QUALITY ASSURANCE/ QUALITY CONTROL

The following general QA procedures apply:

1. All data must be documented on Air Sampling Worksheets or within site logbooks.

2. All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation and they must be documented.

The following specific QC activities apply:

1. Provide one field blank per sampling event or per 20 samples, whichever is greater. The field blank should be handled in the same manner as the sampling tube (break, seal, and transport) except that no air is drawn through it.

2. Collect one collocated sample per sampling event or per 10 samples, whichever is greater. Collocated samples are two samples collected adjacent to each other during the same time period at the same flow rates.

3. Include a minimum of one lot blank tube per manufacturer's lot of tube utilized per sampling event. These tubes are taken directly from the charcoal tube box. Do not break the ends.

10.0 DATA VALIDATION

Results of the quality control samples will be evaluated for contamination. This information will be utilized to qualify the environmental sample results accordingly with the project's data quality objectives.

11.0 HEALTH AND SAFETY

When working with potential hazardous materials, follow U.S. EPA, OSHA and corporate health and safety procedures.

Specific hazards unique to charcoal tube sampling include:

1. Sharp edges associated with the tubes after they have been "cracked."

2. Walking and working surfaces, as well as possible heights, associated with access to sampling locations.

12.0 REFERENCES

(1) Eiler, Peter M., ed. NIOSH Method 1501, Aromatic Hydrocarbons. In: *NIOSH Manual of Analytical Methods*, Third Edition, U.S. Gov.'t Printing Office, Washington, D.C., 1987. p. 1501-1.

(2) Eiler, Peter M., ed. NIOSH Method 1500, Hydrocarbons, BP 36-126°C. In: *NIOSH Manual of Analytical Methods*, Third Edition, U.S. Gov.'t Printing Office, Washington, D.C., 1987. p. 1500-1.

(3) Eiler, Peter M., ed. NIOSH Method 1003, Halogenated Hydrocarbons. In: *NIOSH Manual of Analytical Methods*, Third Edition, U.S. Gov.'t Printing Office, Washington, D.C., 1987. p. 1003-1.